CURRENT LITERATURE

NOTES FOR STUDENTS

Age changes in leaves.—An interesting and important paper by BENEDICT[1] is an attempt to answer the question whether general progressive age changes occur during the vegetative life of a woody perennial, and constitutes, so far as the reviewer's knowledge goes, the first positive evidence based on exact observation for an affirmative answer to the question. The author approaches his subject with a brief résumé of the physiological and morphological age changes in animals, pointing out that much more attention has been paid to the phenomena of senescence in animals than in plants, there being as regards plants practically no really conclusive data at hand. He emphasizes both the scientific and the practical importance of the question whether plants actually grow old, and notes that in view of the great differences in length of life in different animal species the very great length of life attained by certain trees does not constitute any real answer to the question.

As the chief material for his own study of senescence in plants the author has chosen the leaves of the wild grape (*Vitis vulpina* L.) for various excellent reasons noted in the paper, and his observations concern primarily the size of the aggregations of photosynthetically active cells, the vein islets in the meshes of the network of veinlets, or in other words the size of these meshes. Briefly stated, the chief results of the paper are these: The size of the vein islets is essentially the same in different regions of the same leaf and in leaves of different size and thickness from plants of the same or nearly the same age, and differs but slightly with ordinary differences of light and shade. A comparison of minimum and maximum areas of the vein islets in different leaves of the same plant also shows much less variation than the areas and thicknesses of the leaves themselves. All these facts indicate that the size of the vein islets is governed by some internal characteristic of the plant as a whole, or more specifically of the meristematic tissue. The ground being thus cleared, the next step is the comparison of the size of the vein islets in the leaves of plants of different ages, age being determined by the number of rings in the main trunk or in some extreme cases by the size of the trunk. The very extensive series of measurements show beyond question that the size of the vein islets is greatest in the youngest plants and undergoes a progressive decrease with advancing age. This difference in size holds good for immature as well as for mature leaves, and also for cuttings from plants of different age as well as for the plants

[1] BENEDICT, H. M., Senile changes in leaves of *Vitis vulpina* L. and certain other plants. Cornell Univ. Agric. Exp. Sta. Memoir no. 7. pp. 281–370. 1915.

themselves; that is, vegetative propagation does not bring about rejuvenescence in this respect. The rate of decrease in the size of the vein islets is highest in the earlier years of life of the vine and decreases in later years, and when plotted as a curve shows a decrease in steepness and approach to horizontal with advancing age. The identity of type of this curve with the curve of decrease in pulse rate in human beings and the decrease in rate of growth in guinea-pigs is strikingly shown by graphic comparison.

These observations on *Vitis vulpina* are supplemented by less complete data on other woody perennials: *V. bicolor*, *Tecoma radicans*, and a number of trees, including species of *Salix*, *Castanea*, *Quercus*, *Tilia*, *Ulmus*, *Carya*, *Acer*, *Platanus*, and *Fraxinus*, all of which lead to the same conclusions, as do also observations on several pedigreed varieties of grape which have been propagated by cuttings for known different lengths of time. Other age changes determined in the leaves of *Vitis* are decrease in rate of CO_2 production, decrease in imbibition of water by powdered leaves, decrease in acidity, increase in number and decrease in size of stomata, and probably a decrease in size of palisade cells and an increase in the proportion of cytoplasm to nucleus.

In the discussion particular attention is called to the significance of these facts in connection with the question of the deterioration and running out of cultivated fruits and other plants propagated by vegetative means, and then, after criticism of some of the various theories of senescence based primarily on zoological data, BENEDICT concludes that a decrease in permeability of the cells will best account for the observed facts. With this decrease in permeability of the photosynthetic cells, diffusion of water and salts through them is retarded, and the results obtained by various investigators indicate that lack of water in the cells of the leaf stimulates the production of veinlets. He points out, however, that this decrease in permeability with advancing age is itself dependent upon the properties of colloids, and that the fundamental factors of senescence are to be found in the properties of the protoplasmic colloids.

The reviewer welcomes this paper, not only for its scientific and practical significance, but also as affording in general confirmatory evidence for his own conclusions based on an experimental study of certain simple animals, and for certain suggestions concerning senescence and rejuvenescence in plants. It seems worth while to point out, however, that changes in the meristematic tissue, such as BENEDICT has discovered, are not the only age changes in the plant. The cells which differentiate from the meristematic tissue undoubtedly grow old much more rapidly than the meristematic tissue. The changes in the meristematic tissue of *Vitis* which determine the decrease in size of the vein islets must be at most only the earliest stages of senescence. Differentiation in any appreciable degree is not yet present in this tissue, but that is no reason why it may not become an important factor in more advanced stages of senescence. Protoplasmic differentiation is undoubtedly of less significance in this respect than in animals, where its relation to senescence is evident.

It may also be pointed out that a period of senescence which seems when viewed superficially to be uniformly progressive may be made up of many alternating periods or cycles. There is evidence that in at least many cases the cell undergoes changes in the direction of senescence between divisions, and in the direction of rejuvenescence at division. It may be that the very slow aging of the meristematic tissues of plants, as compared with that of cells which cease to divide, is associated with the frequent occurrence of division. Likewise, the localization and outgrowth of a new growing tip, even in meristematic tissue, must involve, at least often, a slight rejuvenescence of the cells concerned. Thus the progressive senescence of the meristematic tissue in such a case as that of *Vitis* may consist of innumerable periods of alternate slight senescence or retardation and rejuvenescence or acceleration, in which the latter does not quite balance the former. In many of the lower plants, as in certain of the lower animals, such changes apparently do balance each other, at least under some conditions, and vegetative or agamic reproduction or propagation may be continued indefinitely. In general, the evidence seems to indicate that this balance is more complete in the simpler organisms, and that rejuvenescence becomes more and more limited to gametic reproduction as evolution advances.

BENEDICT finds that the rate of decrease in size of the vein islets becomes lower with advancing age in *Vitis*. This suggests the possibility that sooner or later a balance between the shorter periods of senescence and rejuvenescence may be reached, and if such a possibility is ever realized the period of "maturity" may continue indefinitely.

BENEDICT is inclined to minimize the importance of the accumulation of relatively inactive components in the protoplasm as a factor in senescence and to lay chief stress on decrease in permeability. While decrease in permeability is undoubtedly an important factor in senescence, the reviewer has pointed out elsewhere that such a change is merely the surface expression of changes in the colloids or in the protoplasmic substratum, and that similar changes on other limiting surfaces or throughout the substratum may determine differentiation, accumulation of structural substance, and decrease in metabolic rate. In short, decrease in permeability seems to be merely one expression of the great variety of changes concerned in bringing about the decrease in metabolic rate characteristic of senescence. Moreover, it was pointed out above that the changes with which BENEDICT is concerned can be only the earliest stages of senescence in the meristematic tissues. Decrease in permeability may very possibly be one of the chief expressions of these early changes, but certainly in later stages various other factors play important parts.

On the basis of BENEDICT'S conclusions, the changes in permeability of the photosynthetic cells in the leaf must not only interfere with diffusion from cell to cell, but also must decrease metabolic activity within each cell. This

being the case, the question must at least be raised whether the demand for water and nutrients is greater or less in the older than in the younger vein islets. It seems not impossible that the decreasing metabolic activity with advancing age in the vascular tissues themselves may be a factor in determining the increase in the veinlets. The reviewer has shown that the spatial relations of successively arising parts may vary directly with the metabolic rate, and it is perhaps allowable to suggest that in this case the more frequent branching of the veinlets in the older leaves may be to some extent associated with a lower metabolic rate in each new branch, and consequently a lower limit of distance within which it inhibits the development of new veinlets.

In conclusion, it must be noted that BENEDICT'S use of the terms "senile" and "senility" is at least unusual. These terms are commonly used only with reference to the extreme stage of senescence preceding death in man and the higher animals, where actual atrophy, degeneration, and necrosis of cells occur, but BENEDICT speaks of senile changes occurring in the early stages of development. To substitute "senile" and "senility" for "aging" and "senescence" is simply to give the former terms a new meaning. To speak of meristematic tissue or of a plant in "vigorous maturity" as senile is to a zoologist or animal physiologist little less than a contradiction in terms. Moreover, the increase in vascular tissue in the leaf with advancing age of the plant is scarcely comparable to the replacement of atrophied organs by connective tissue in man and the higher animals, but resembles rather the increase in stable morphological structure which occurs during development in animals. Criticism of such points, however, does not detract from the interest and significance of BENEDICT'S evidence for the occurrence of a gradual, progressive change, slight, but apparently in the direction of senescence, in the meristematic tissues during vegetative life.—C. M. CHILD.

Cecidiology.—American botanists will be interested in a posthumous paper on American insect galls by THOMPSON.[2] In part I, the galls are classified under the generic names of the host plants, with subordinate grouping based on the host plant. The descriptions are very brief, in most cases restricted to a single line, but give the specific names of the host plants and statements as to anatomy. This first part will prove very useful to botanists. Part II groups the galls with reference to the insects causing them and gives a list of host plants for each. This part also includes a bibliography and a lengthy supplemental list which includes a few fungus galls. The illustrations are good and the entire publication will prove very helpful.

American botanists will also be interested in a paper by STEWART[3] on the anatomy of *Gymnosporangium* galls. This paper is summarized as follows:

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[2] THOMPSON, M. T., An illustrated catalogue of American insect galls. pp. 66. *pls. 21.* 1915. Edited by Dr. E. P. FELT.

[3] STEWART, ALBAN, An anatomical study of *Gymnosporangium* galls. Amer. Jour. Bot. 2:402–417. 1915.